MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210 & TERM ID 2215)

DME5096 – STRENGTH OF MATERIALS

(Diploma in Mechanical Engineering)

18 FEBRUARY 2023
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 6 pages excluding the cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1 (25 marks)

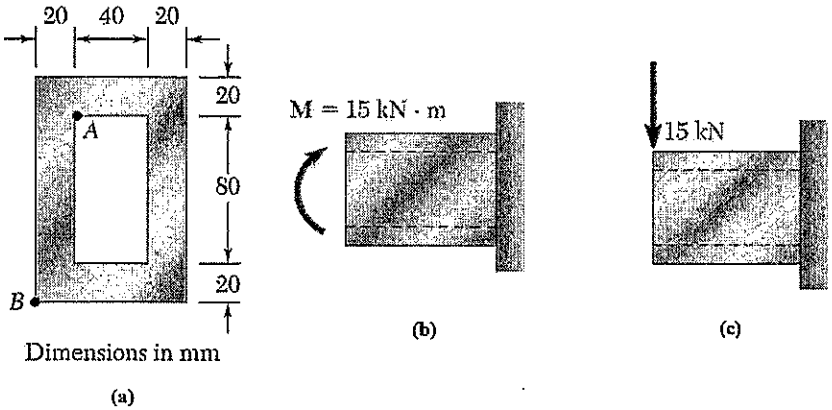


Figure Q1

Figure **Q1(a)** shows cross section of a cantilever beam that is subjected to a couple in a vertical plane as shown in figure **Q1(b)**. Determine the stress at:

(a) point A,

[11 marks]

(b) point B.

[4 marks]

If the couple is replaced with a vertical downward force as shown in **Figure Q1(c)**, then determine the shear stress at

(c) point A,

[7 marks]

(d) point B.

[3 marks]

Continued ...

Question 2 (25 marks)

Figure Q2 shows a beam that is subjected to a point load P.

(a) Using double integration method, determine the equation of the elastic curve for the beam using the x coordinate that is valid for $0 \leq x \leq L/2$. [13 marks]

(b) Specify the slope at A and the beam's maximum deflection. [9 marks]

(c) Verify your answers using superposition method. EI is constant. [3 marks]

Draw all the relevant free body diagrams to get the full marks.

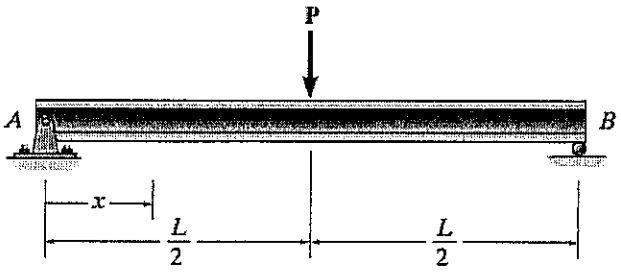


Figure Q2

Question 3 (25 marks)

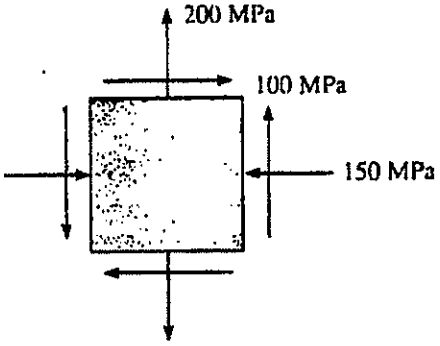


Figure Q3

The state of plane stress at a point is represented by the element shown in **Figure Q3**. Determine

(a) the principal planes and corresponding stresses, [11 marks]

(b) the maximum in-plane shear stress and its plane and the associated average normal stress, [6 marks]

(c) the state of stress on another element at the same point, but rotated by 25° clockwise from the position shown. [8 marks]

(Construct a Mohr Circle first before showing your each solution)

Continued ...

Question 4 (25 marks)

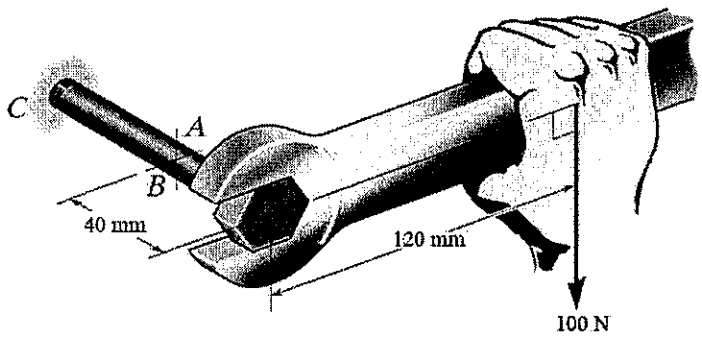


Figure Q4

The bolt is fixed to its support at C. If a force of 100 N is applied to the wrench to tighten it, determine

(a) the normal and shearing stresses at point A, [11 marks]

(b) the normal and shearing stresses at point B, [6 marks]

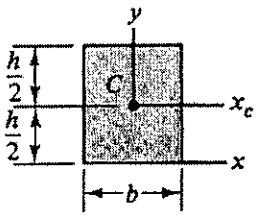
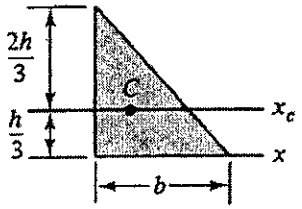
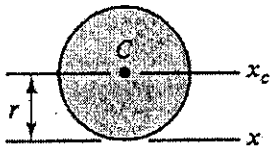
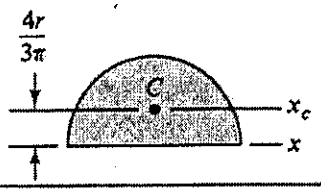
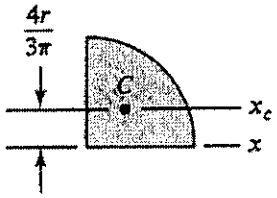
(c) principal stresses (magnitudes and directions) developed in the bolt shank at point A. [8 marks]

The shank has a diameter of 6 mm. Draw all the relevant free body diagrams to obtain the full mark.

Continued ...

Appendix A

Moments of Inertia of Simple Shapes

Shapes		I_x	I_{x_c}
Rectangle		$\frac{bh^3}{3}$	$\frac{bh^3}{12}$
Triangle		$\frac{bh^3}{12}$	$\frac{bh^3}{36}$
Circle		$\frac{5\pi r^4}{4}$	$\frac{\pi r^4}{4}$
Semicircle		$\frac{\pi r^4}{8}$	$0.0349\pi r^4$
Quarter-circle		$\frac{\pi r^4}{16}$	$0.01747\pi r^4$

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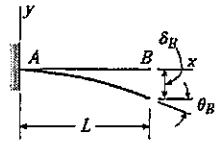
Appendix B

TABLE G-1 DEFLECTIONS AND SLOPES OF CANTILEVER BEAMS



v = deflection in the y direction (positive upward)
$v' = dv/dx$ = slope of the deflection curve
$\delta_B = -v(L)$ = deflection at end B of the beam (positive downward)
$\theta_B = -v'(L)$ = angle of rotation at end B of the beam (positive clockwise)
EI = constant

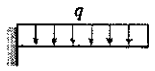
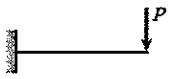
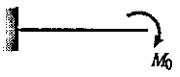
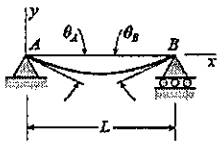
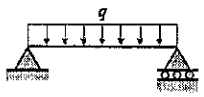
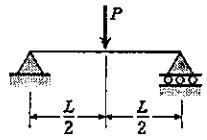
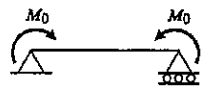
1		$v = -\frac{qx^2}{24EI}(6L^2 - 4Lx + x^2) \qquad v' = -\frac{qx}{6EI}(3L^2 - 3Lx + x^2)$ $\delta_B = \frac{qL^4}{8EI} \qquad \theta_B = \frac{qL^3}{6EI}$
4		$v = -\frac{Px^2}{6EI}(3L - x) \qquad v' = -\frac{Px}{2EI}(2L - x)$ $\delta_B = \frac{PL^3}{3EI} \qquad \theta_B = \frac{PL^2}{2EI}$
6		$v = -\frac{M_0x^2}{2EI} \qquad v' = -\frac{M_0x}{EI}$ $\delta_B = \frac{M_0L^2}{2EI} \qquad \theta_B = \frac{M_0L}{EI}$

TABLE G-2 DEFLECTIONS AND SLOPES OF SIMPLE BEAMS



EI = constant

v = deflection in the y direction (positive upward)
$v' = dv/dx$ = slope of the deflection curve
$\delta_C = -v(L/2)$ = deflection at midpoint C of the beam (positive downward)
x_1 = distance from support A to point of maximum deflection
$\delta_{max} = -v_{max}$ = maximum deflection (positive downward)
$\theta_A = -v'(0)$ = angle of rotation at left-hand end of the beam (positive clockwise)
$\theta_B = v'(L)$ = angle of rotation at right-hand end of the beam (positive counterclockwise)

1		$v = -\frac{qx}{24EI}(L^3 - 2Lx^2 + x^3)$ $v' = -\frac{q}{24EI}(L^3 - 6Lx^2 - 4x^3)$ $\delta_C = \delta_{max} = \frac{5qL^4}{384EI} \qquad \theta_A = \theta_B = \frac{qL^3}{24EI}$
4		$v = -\frac{Px}{48EI}(3L^2 - 4x^2) \qquad v' = -\frac{P}{16EI}(L^2 - 4x^2) \qquad \left(0 \le x \le \frac{L}{2}\right)$ $\delta_C = \delta_{max} = \frac{PL^3}{48EI} \qquad \theta_A = \theta_B = \frac{PL^2}{16EI}$
10		$v = -\frac{M_0x}{2EI}(L - x) \qquad v' = -\frac{M_0}{2EI}(L - 2x)$ $\delta_C = \delta_{max} = \frac{M_0L^2}{8EI} \qquad \theta_A = \theta_B = \frac{M_0L}{2EI}$

Appendix C

Axial Loading

$$\delta = \frac{PL}{EA} \qquad \varepsilon = \frac{\Delta L}{L_0} \qquad \sigma = \frac{P}{A_0} \qquad \frac{\Delta V}{V_0} = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - \nu(\sigma_y + \sigma_z)\right] \qquad \varepsilon_y = \frac{1}{E}\left[\sigma_y - \nu(\sigma_x + \sigma_z)\right] \qquad \varepsilon_z = \frac{1}{E}\left[\sigma_z - \nu(\sigma_x + \sigma_y)\right]$$

Torsion

$$\tau = \frac{Tr}{J} \qquad \Phi = \frac{TL}{JG} \qquad \frac{T_1}{r_1} = \frac{T_2}{r_2} \qquad \gamma = \frac{\rho\phi}{L} \qquad r_1\omega_1 = r_2\omega_2 \qquad P = T\omega$$

Polar moment of inertia of a circle of radius r $\quad J = \frac{\pi}{2}r^4$

Polar moment of inertia of a ring of inner radius r_2 and outer radius r_1 $\quad J = \frac{\pi}{2}{r_1}^4 - \frac{\pi}{2}{r_2}^4$

Pure Bending and Transverse Loading

$$\sigma_x = -\frac{My}{I} \qquad \sigma_{max} = \frac{Mc}{I} = \frac{M}{S} \qquad \varepsilon_x = -\frac{y}{\rho} \qquad \tau = \frac{VQ}{It} \qquad \tan\phi = \frac{I_z}{I_y}\tan\theta$$

$$I_{x'} = I_x + Ad^2$$

For circular shaft $\tau = \frac{VQ}{It}$, $\tau_{max} = \frac{4V}{3A}$

Distance to center of geometry from the y-axis $\quad \bar{y} = \frac{\sum yA}{\sum A}$

Relations between bending moment M, shear force V, and intensity q of distributed load.

$$\frac{dV}{dx} = -q \qquad \frac{dM}{dx} = V$$

End of Paper